AIR-CONDITIONING
& REFRIGERATION
INSTITUTE

Representing Manufacturers
of Heating, Ventilating,
Air-Conditioning and
Refrigeration Products

November 4, 2003

Mr. Michael J. McCabe
Program Manager, Building Technology Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585

Dear Mr. McCabe:

Thank you for your letter of July 25, 2003, and for meeting with us on October 1, 2003 regarding Single Packaged Vertical Units (SPVUs). After a careful review of your letter, the Air-Conditioning and Refrigeration Institute (ARI) has come to the same conclusion as the Department of Energy (DOE), that Addendum d to ASHRAE 90.1-2001 does not accomplish what was intended.

ARI originally submitted a continuous maintenance proposal to ASHRAE 90.1 to establish SPVUs as a new product class of small and large commercial package air conditioning and heating equipment. Our proposal to ASHRAE was prompted by DOE's determination in the Notice of Proposed Rulemaking for residential central air conditioners and heat pumps[1] that SPVUs were commercial products covered by the Energy Policy Act of 1992 (EPACT). Addendum d to ASHRAE 90.1-2001 sets a new product class for single packaged vertical air conditioners (SPVAC) and heat pumps (SPVHP) with an appropriate test procedure (ARI 390-2001) and minimum efficiency standards of 8.6 EER/2.7 COP at all cooling capacities. However, DOE's examination of Addendum d revealed some deficiencies with ARI 390-2001 (e.g.; scope and definition) as well as with the minimum efficiency standards which were inconsistent with current federal regulations. ARI agrees with DOE's findings and is taking the following steps to resolve the concerns raised about Addendum d:

ARI Standard 390

DOE rightfully noted that Section 2.2 of ARI 390 as originally drafted excluded nearly all of the products that meet ARI 390's definition for SPVAC and SPVHP. ARI agrees with DOE that ARI 390 should not exclude small and large commercial equipment as

[1] Federal Register/Vol. 65, No. 194, page 59610, dated October 5, 2000

defined in other ARI standards (i.e.; ARI 210/240, ARI 340/360). Consequently, Section 2.2 of ARI 390 was revised not to exclude any equipment.

DOE suggested that ARI 390 include a subsection under Section 2 on "Applicability" to exclude other rating standards (i.e.; ARI 210/240, ARI 340/360) from applying to SPVUs. Excluding other standards from applying to SPVUs would mean that there is only one testing and rating standard for SPVUs, i.e.; ARI 390. We agreed with DOE's suggestion and have included a subsection under Section 2 on "Applicability".

DOE recommended that SPVAC and SPVHP be defined with greater precision to avoid unintended overlap with existing product categories under the Energy Policy and Conservation Act (EPCA). ARI agrees with the recommendation and has revised Section 3.10 to define SPVAC and SPVHP as a type of air-cooled small or large commercial package air conditioning and heating equipment. In addition, to avoid an overlap with the definition of packaged terminal equipment, we deleted the term "unencased" from the definition.

I have attached as Exhibit 1 a revised copy of ARI standard 390 with strikeout and underline that highlight deletions and additions we made to the document. ARI welcomes any feedback DOE might have that would further improve ARI standard 390.

Efficiency Standards and ASHRAE 90.1

The Department correctly noted that in some categories Addendum d lowered the existing commercial air-conditioning equipment standards established under EPCA. This is particularly true for air cooled central air conditioners and heat pumps between 65,000 and 135,000 btu/h, and between 135,000 and 240,000 btu/h. It was not ARI's intention to propose efficiency standards below minimum federal levels. However, by focusing on moving single-phase SPVUs less than 65,000 btu/h out of the National Energy Conservation Act (NAECA) regulations and into EPACT, we lost track of the fact that 3-phase SPVUs below and above 65,000 btu/h were already covered by federal regulations. To correct this oversight, ARI intends to propose to ASHRAE 90.1 the following efficiency standards:

a) Equipment Less Than 65,000 Btu/h
For both single-phase and 3-phase equipment, ARI will propose a minimum Energy Efficiency Ratio (EER) of 8.9 for SPVACs and a minimum EER of 8.9 and Coefficient of Performance (COP) at 47^{o}F of 2.7 for SPVHPs.

The use of an EER/COP energy efficiency descriptor is a significant change from the Seasonal Energy Efficiency Ratio (SEER) and Heating Seasonal Performance Factor (HSPF) descriptors used to rate 3-phase central air conditioning and heat pumps less than 65,000 btu/h. ARI opted for an EER/COP descriptor because of the intended use of SPVUs which is markedly different from residential central air conditioners and heat pumps for which the SEER and HSPF descriptors were

originally developed. SPVUs are primarily used in schools, telecommunication shelters, modular buildings, and are subject to different duty cycles and operating hours than what is typically encountered in residential applications. The federal test procedures used to determine the SEER/HSPF ratings are intended to capture the seasonal performance of central air conditioners and heat pumps in a residential setting. They are clearly not appropriate to rate SPVUs.

There being no direct physical relationship between SEER/HSPF and EER/COP, ARI collected information on SEER, EER, HSPF and COP from SPVU manufacturers and plotted the data in three separate graphs. Exhibits 2 and 3 show the relationship between SEER and EER for SPVACs and SPVHPs respectively. It can be seen from the figures that the current minimum federal energy efficiency standards of 9.7 SEER is equivalent to an EER of 8.5. In other words, all SPVUs complying with the current federal minimum standard of 9.7 SEER would still be compliant if the minimum federal standard is changed to 8.5 EER. However, in an effort to further decrease the energy consumption of SPVUs, ARI has proposed a minimum EER of 8.9.

Similarly, Exhibit 4 shows the relationship between HSPF and COP for SPVHPs. The figure indicates that the current federal minimum standard of 6.6 HSPF is equivalent to a COP of 2.7. All SPVHPs currently meeting the 6.6 HSPF would still be compliant with federal regulations if the minimum federal standard is changed to 2.7 COP. ARI considered proposing a higher COP level than 2.7, but decided against once it became apparent that a higher COP would be eliminating a significant number of current SPVU models. However, ARI is committed, through ASHRAE 90.1, to periodically review in the future the performance of SPVHPs (and SPVACs) and to amend the minimum COP and EER at levels that are economically justified and technologically feasible.

b) Equipment Between 65,000 and 135,000 Btu/h
Addendum d inadvertently lowered the existing minimum federal standards for this equipment category. To correct this oversight, ARI will propose a minimum EER of 8.9 for SPVACs and a minimum EER of 8.9 and a minimum COP at 47°F of 3.0 for SPVHPs. These levels are consistent with current federal regulations.

c) Equipment Between 135,000 and 240,000 Btu/h
In this equipment category, Addendum d lowered the existing minimum federal standard by establishing a COP of 2.7 (the current federal minimum standard is 2.9). ARI will propose a minimum COP at 47°F of 2.9 for SPVHPs and a minimum EER of 8.6 for both SPVACs and SPVHPs. The proposed EER is greater than the existing federal minimum EER of 8.5.

Future Actions

ARI intends to submit a continuous maintenance proposal to ASHRAE with the proposed minimum energy efficiency standards listed above for consideration by the ASHRAE 90.1 committee at the 2004 winter meeting in Anaheim, California. In addition to the proposed minimum efficiency standards, the proposal will also include a definition for SPVAC and SPVHP identical to the definition found in the revised ARI standard 390 (Sections 3.10 and 3.11). ARI will share a copy of the proposal with DOE for review and comments before submitting it to ASHRAE.

We hope that the aforementioned actions taken by ARI will ease the legitimate concerns raised by DOE. We would like to take this opportunity to thank you for your guidance and help and welcome any additional feedback you may have in moving this issue forward.

Regards,

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Attachment: As stated

Cc: Maureen Murphy, Department of Energy
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1st Draft, October 10, 2003

EXHIBIT 1

20013

STANDARD for

PERFORMANCE RATING OF SINGLE PACKAGE VERTICAL AIR-CONDITIONERS AND HEAT PUMPS

Standard 390

IMPORTANT

SAFETY DISCLAIMER

ARI does not set safety standards and does not certify or guarantee the safety of any products, components or systems designed, tested, rated, installed or operated in accordance with this standard/guideline. It is strongly recommended that products be designed, constructed, assembled, installed and operated in accordance with nationally recognized safety standards and code requirements appropriate for products covered by this standard/guideline.

ARI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. ARI does not certify or guarantee that any tests conducted under its standards/guidelines will be non-hazardous or free from risk.

~~**IMPORTANT**~~

~~***SAFETY RECOMMENDATIONS***~~

~~It is strongly recommended that the product be designed, constructed, assembled and installed in accordance with nationally recognized safety requirements appropriate for products covered by this standard.~~

~~ARI, as a manufacturers' trade association, uses its best efforts to develop standards employing state-of-the-art and accepted industry practices. However, ARI does not certify or guarantee safety of any products, components or systems designed, tested, rated, installed or operated in accordance with these standards or that any tests conducted under its standards will be non-hazardous or free from risk.~~

Note:

This ~~is a new~~ standard supersedes ARI 390-2001.

Price $10.00 (M) $20.00 (NM)
Printed in U.S.A.

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SINGLE PACKAGE VERTICAL AIR-CONDITIONERS AND HEAT PUMPS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish, for Single Package Vertical Air-Conditioners and Heat Pumps equipment: definitions; classifications; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions.

1.1.1 *Intent.* This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 *Review and Amendment.* This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *Scope.* This standard applies to factory-made assembled commercial and or industrial Single Package Vertical Air- Conditioners and Heat Pump equipment as defined in Section 3.

2.1.1 *Applicability*. ARI Standard 210/240 and ARI Standard 340/360 shall not apply to commercial or industrial equipment covered by this Standard.

2.1.12.1.2 *Energy Source*. This standard applies to electrically operated, vapor-compression refrigeration systems.

2.1.22.1.3 *Installation*. The SPVAC/SPVHP Single Package Vertical Air- Conditioner and Heat Pump is intended for ducted or non-ducted installation with field or factory supplied grilles.

2.2 *Exclusions.* This standard does not apply to the following products or equipment:

None.

2.2.1 Heat operated air-conditioning/heat pump equipment or to room air-conditioners/heat pumps.

2.2.2 Packaged terminal air-conditioners and heat pumps as defined in ANSI/ARI Standard 310/380, *Packaged Terminal Air-Conditioners and Heat Pumps*, or to water-to-air and brine-to-air heat pumps as defined in ISO 13256-1, *Water Source Heat Pumps-Testing and Rating for Performance.*

2.2.3 Unitary air-conditioners and air-source unitary heat pumps as defined in ARI Standard 210/240, *Unitary Air-Conditioning and Air-Source Heat Pump Equipment*, with capacities less than 65,000 Btu/h [19 000W].

2.2.4 Commercial and industrial unitary air-conditioners and heat pumps as defined in ARI Standard 340/360, *Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, with capacities 65,000 Btu/h [19 000W] or greater.

Section 3. Definitions

All terms in this document shall follow the standard industry definitions in the current edition of *ASHRAE Terminology of Heating, Ventilation, Air Conditioning and Refrigeration* unless otherwise defined in this section.

3.1 *Coefficient of Performance (COP).* A ratio of Cooling/Heating Capacity in watts [W] to the power input values in watts [W] at any given set of rRating cConditions expressed in watts/watt [W/W]. For heating *COP*, supplementary resistance heat shall be excluded.

3.1.1 *Standard Coefficient of Performance*. A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.2 *Cooling Capacity.* The capacity associated with the change in air enthalpy which includes both the Latent and Sensible Capacities expressed in Btu/h [W].

3.2.1 *Latent Capacity*. Capacity associated with a change in humidity ratio.

3.2.2 *Sensible Capacity*. Capacity associated with a change in dry-bulb temperature.

3.3 *Defrost Range*. Ambient conditions such that a heat pump operating in the heating mode will develop frost on the outdoor coil to the extent that temperature ranges/tolerances specified in Table 4 of ANSI/ASHRAE Standard 37 will be exceeded.

3.4 *Energy Efficiency Ratio (EER).* A ratio of the Cooling Capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/(W·h).

3.4.1 *Standard Energy Efficiency Ratio.* A ratio of the capacity to power input value obtained at Standard Rating Conditions.

3.5 *Heating Capacity*. The capacity associated with the change in dry-bulb temperature expressed in Btu/h [W].

3.6 *Integrated Part-Load Value (IPLV).* A single number part-load efficiency figure of merit calculated per the method described in this standard.

3.7 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.7.1 *Application Rating*. A rating based on tests performed at Application Rating cConditions (other than Standard Rating Conditions).

3.7.2 *Standard Rating*. A rating based on tests performed at Standard Rating Conditions.

3.8 *Rating Conditions.* Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.8.1 *Standard Rating Conditions*. Rating cConditions used as the basis of comparison for performance characteristics.

3.9 *"Shall" or "Should".* "Shall" or "should" shall be interpreted as follows:

3.9.1 *Shall.* Where "shall" or "shall not" is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

3.9.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

3.10 *Single Package Vertical Air-Conditioner (SPVAC).* Is a type of air-cooled small or large commercial package air conditioning and heating equipment; factory assembled as a single package having its major components arranged vertically, which is an separate encased or unencased combination of cooling and optional heating components; is, factory assembled as a single package, and intended for exterior mounting on, adjacent interior to, or through, an outside wall; and is powered by single or three phase current. Unit major components are arranged vertically, and It may contain separate indoor grille(s), outdoor louvers, various ventilation options, indoor free air discharge, ductwork, wall plenum or sleeve. Heating components may include electrical resistance, steam, hot water, gas or no heat, but may not include reverse cycle refrigeration as a heating means.

3.10.1 *SPVAC Functions*. *SPVAC* either alone or in combination with a heating plant, shall provide air-circulation, air-cleaning, cooling with controlled temperature and dehumidification, and may optionally include the function of heating and possible humidifying and ventilation.

3.11 *Single Package Vertical Heat Pump (SPVHP).* Is aA SPVAC that utilizesseparate encased or unencased combination of heating and optional cooling components, factory assembled as a single package, and intended for exterior mounting on, adjacent interior to, or through, an outside wall. Unit major components are arranged vertically, and may contain separate indoor grille(s), outdoor louvers, various ventilation options, indoor free air discharge, ductwork, wall plenum or sleeve. Its primary heating means shall be reverse cycle refrigeration as its primary heat source, with secondary supplemental heating by means of electrical resistance, steam, hot water or gas.

~~**3.11.1** *SPVHP Functions*. *SPVHP* shall provide the functions of air heating with controlled temperature, air-cooling, air-circulating, air-cleaning, dehumidifying or humidifying and ventilation.~~

3.12 *Standard Air*. Air weighing 0.075 lb/ft3 [1.2 kg/m3] which approximates dry air at 70°F [21°C] and at a barometric pressure of 29.92 in Hg [101.3 kPa].

Section 4. Classifications

4.1*Classifications*. SPVAC/ and SPVHP equipment within the scope of this standard shall be classified as shown in Tables 1 and 2.

Section 5. Test Requirements

5.1 *Test Requirements*. Standard Published Ratings shall be established at the Standard Rating Conditions specified in 5.2 or 5.3 and. Standard Ratings shall be verified by tests conducted in accordance with ANSI/ASHRAE Standard 37.

5.2 *Standard Rating Tests.* Test to determine Standard Rating shall be establish at the Standard Rating Conditions specified in Table 3. indicates the tests and test conditions which are required to determine values of standard capacity ratings and energy efficiency.

5.2.1 *Electrical Conditions.* Nameplate voltages are shown in Table 1 of ARI Standard 110. Standard Rating Tests shall be performed at the nameplate rated voltage and frequency unless otherwise specified in this Standard.

For equipment which is rated with 208/230 dual nameplate voltages and less than 65,000 Btu/h [19 000 W] cooling, Standard Rating Tests shall be performed at 230 V.

For all other dual nameplate voltage equipment covered by this standard, the Standard Rating Tests shall be performed at both voltages or at the lower voltage if only a single Standard Rating is to be published.

Table 1. Classification of Single Package Vertical Air-Conditioners

Types of SPVAC Equipment			
Designation	ARI Type†	Heat Rejection	Arrangement
Single Package	SPV-A	Air	FAN / COMP EVAP / COND

† A suffix of "-O" indicates equipment not intended for use with field-installed duct systems (See 5.2).

Table 2. Classification of Single Package Vertical Heat Pumps

Types of SPVHP Equipment		
Designation	ARI Type† Heating and Cooling	Arrangement
Single Package	HSPV-A	FAN / INDOOR COIL COMP / OUTDOOR COIL

† A suffix of "-O" indicates equipment not intended for use with field-installed duct systems (See 5.2).

Table 3. Operating Conditions for Standard Rating and Performance Tests Operating Requirements

		Indoor Side Air Entering		Outdoor Side Air Entering	
	Test	Dry Bulb °F [°C]	Wet Bulb °F [°C]	Dry Bulb °F [°C]	Wet Bulb °F [°C]
COOLING	Standard Rating Conditions, Cooling[1]	80.0 [26.7]	67.0 [19.4]	95.0 [35.0]	75.0[4] [23.9]
	Low Temperature Operation, Cooling	67.0 [19.4]	57.0 [13.9]	67.0 [19.4]	57.0[4] [13.9]
	Maximum High Temperature Operation	80.0 [26.7]	67.0 [19.4]	115.0 [46.1]	75.0[4] [23.9]
	Insulation Effectiveness	80.0 [26.7]	75.0 [23.9]	80.0 [26.7]	75.0[4] [23.9]
	Condensate Disposal	80.0 [26.7]	75.0 [23.9]	80.0 [26.7]	75.0[4] [23.9]
	Part-Load Conditions[3]	80.0 [26.7]	67.0 [19.4]	80.0 [26.7]	67.0[4] [19.4]
HEATING	Standard Rating Conditions, High-Temperature Heat Pump, Heating	70.0 [21.1]	60.0 [15.6] (max)	47.0 [8.3]	43.0 [6.1]
	Standard Rating Conditions, Low-Temperature Heat Pump, Heating[2]	70.0 [21.1]	60.0 [15.6] (max)	17.0 [-8.3]	15.0 [-9.4]
	Maximum High-Temperature Operation	80.0 [26.7]	- -	75.0 [23.9]	65.0 [18.3]
	Part-Load Conditions[3]	70.0 [21.1]	60.0 [15.6] (max)	62.0 [16.7]	56.5 [13.6]

NOTES:
1 Same conditions used for voltage tolerance tests.
2 Only required if the manufacturer's Published Ratings include low-temperature specifications.
3 For multiple compressor units or units with compressor capacity modulation.
4 Required when condensate is rejected to the condenser air stream.

Table 4. External Static Pressure

~~Standard~~ Capacity Ratings[1]		Minimum External Static Pressure	
MBtu/h	kW	in H_2O	Pa
≤ 28	≤ 8.2	0.10	25
> 28 and ≤ 42	> 8.2 and 12.4	0.15	37
> 42 and ≤ 70	> 12.4 and ≤ 20.5	0.20	50
> 70 and ≤ 105	> 20.5 and ≤ 30.8	0.25	62
> 105 and ≤ 134	> 30.8 and ≤ 39.3	0.30	75
> 134 and ≤ 210	> 39.6 and ≤ 61.6	0.35	87
> 210 and ≤ 280	> 62.1 and ≤ 82.1	0.40	100
> 280 and ≤ 350	> 82.6 and ≤ 103	0.45	112
> 350 and ≤ 400	> 103.1 and ≤ 117	0.55	137
> 405 and ≤ 500	> 118.6 and ≤ 146	0.65	162
> 500	> 147.9	0.75	187

[1] Cooling Capacity for units with cooling function.

~~For all other dual nameplate voltage equipment covered by this standard, the Standard Rating Tests shall be performed at both voltages or at the lower voltage if only a single Standard Rating is to be published.~~

5.2.2 *Indoor-Side Air ~~f~~Flow Rate*. A~~ll~~ Standard Rating~~s~~ shall be determined at an indoor-side air flow rate as outlined below. ~~All a~~Air flow rates shall be expressed in cfm of Standard Air (scfm).

a. Ducted equipment shall be tested at the air flow rate delivered when operating against the minimum external static pressure specified in Table 4 or at a lower air flow rate if so specified by the manufacturer.

Non-filtered ducted equipment shall be tested at the air flow rate delivered when operating against the minimum external static pressure specified in Table 4 with an additional 0.08 in H_2O [19.9 Pa] of external static pressure.

b. Non-ducted equipment shall be tested at the air flow rates obtained at zero external static pressure. All power consumed by the fan(s) shall be included in the power input to the unit.

c. The manufacturer shall specify a single air flow rate for all tests required in this part of the standard unless the equipment provides automatic adjustment of air flow rate. A separate control signal output for each step of air flow rate shall be considered as an automatic adjustment.

5.2.3 *Outdoor-Side Air F~~f~~low Rate*. A~~ll~~ Standard Rating~~s~~ shall be determined at the outdoor-side air flow rate specified by the manufacturer where the fan drive is adjustable. Where the fan drive is non-adjustable, they shall be determined at the outdoor-side air flow rate inherent in the equipment when operated with all of the resistance elements associated with inlets, louvers, and any ductwork and attachments considered by the manufacturer as normal installation practice. Once established, the outdoor-side air circuit of the equipment shall remain unchanged throughout all tests prescribed herein.

5.2.4 *Part-Load Rating Conditions.* The conditions of test for part-load ratings shall be per Table 3.

The capacity reduction means may be adjusted to obtain the specified step of unloading. No manual adjustment of indoor and outdoor air flow rates from those of the Standard Rating Conditions shall be made. However, automatic adjustment of air flow rates by system function is permissible.

5.2.5 *Moisture Removal Determination.* Indoor air moisture removed shall be determined at Standard Rating Conditions, Cooling. ~~for units tested in accordance with ANSI/ASHRAE Standard~~

~~37.~~

Section 6. Rating Requirements

6.1 *Rating Requirements.* Standard Ratings shall be expressed in Cooling Capacity or Heating Capacity. Power input ratings shall be expressed in increments or multiples of 5 W. Air flow rates shall be expressed in increments of 10 cfm [5 L/s].

6.1.1 *Values of Standard Capacity Ratings.* These ratings shall be expressed only in terms of Btu/h [W] as specified in Table 5.

Table 5. Values of Standard Capacity Ratings

~~Standard~~ Capacity Ratings*		Multiples	
Btu/h x 1000	W x 1000	Btu/h	W
< 20	< 5.9	100	30
= 20 and < 38	= 5.9 and < 11	200	60
= 38 and < 65	= 11 and < 19	500	150
≥ 65 and < 135	≥ 19 and < 39.6	1000	300
≥ 135 and < 400	≥ 39.8 and < 117.0	2000	600
≥ 400	≥ 117.0	5000	1500

* Cooling Capacity for units with cooling function, high temperature Heating Capacity for heating-only units.

6.1.2 *Values of Energy Efficiency Ratio (EER).* Standard measure of Energy Efficiency Ratio, whenever published, shall be expressed in multiples of the nearest 0.05 Btu/W·h for *EER*. Coefficient of Performance *(COP)* for heating or cooling, whenever published, shall be expressed in multiples of the nearest 0.02.

6.2 *Part-Load Rating.* Systems which are capable of capacity reduction shall be rated at 100% and at each step of capacity reduction provided by the refrigeration system(s) as published by the manufacturer. These rating points shall be used to calculate the *IPLV* (see 6.2.1).

6.2.1 *Integrated Part-Load Value (IPLV).* For equipment covered by this standard, the *IPLV* (in *EER*) shall be calculated as follows

a. Determine the capacity and *EER* at the conditions specified in 5.2.

b. Determine the part-load factor (PLF) from Figure 1 at each rating point (see example Appendix C).

c. Use the following equation to calculate *IPLV*:

$$IPLV = (PLF_1 - PLF_2) \times \frac{(EER_1 + EER_2)}{2} + (PLF_2 - PLF_3) \times \frac{(EER_2 + EER_3)}{2} + (PLF_{n-1} - PLF_n) \times \frac{(EER_{n-1} + EER_n)}{2}$$

where:

PLF	=	Part-load factor determined from Figure 1
n	=	Total number of capacity steps
Superscript 1	=	100% capacity and EER at part-load Rating Conditions
Subscript 2, 3 etc.	=	Specific capacity and EER at part-load steps per 6.2

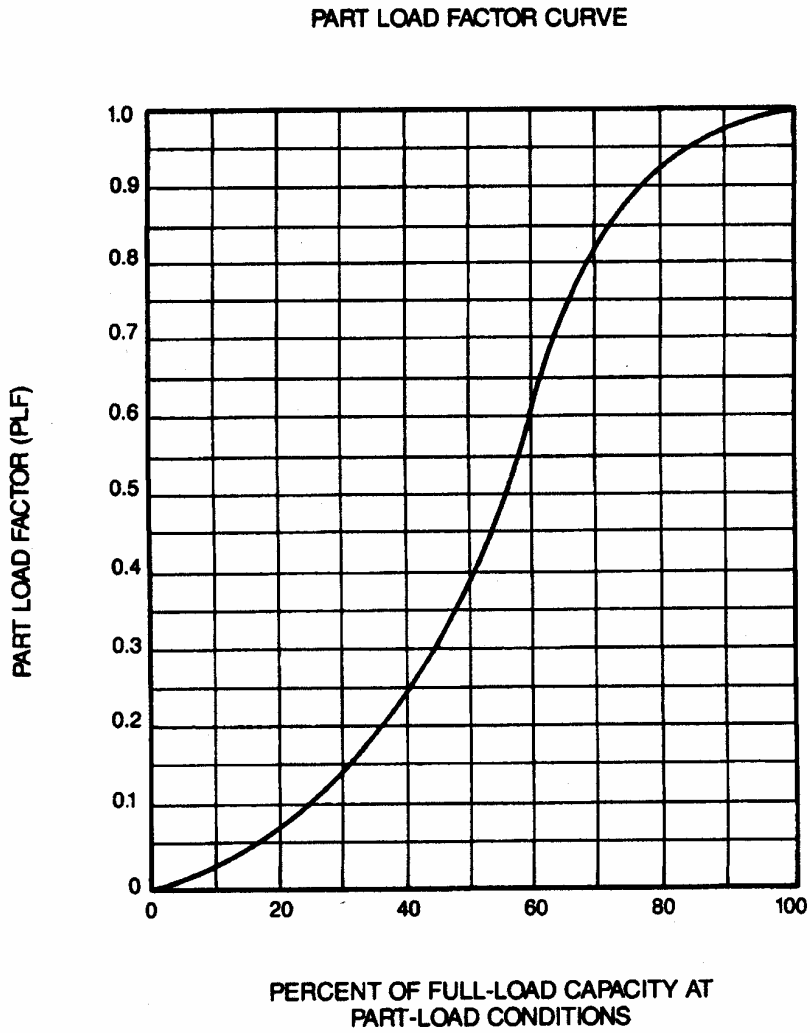
6.3 *Application Ratings.* Ratings at conditions other than those specified in 5.2 and 5.2.4 may be published as Application Ratings, and shall be based on data determined by the methods prescribed in 5.1. Application Ratings in the Defrost Region shall include Heating Capacity and *COP* based upon a complete defrost cycle (from defrost termination to defrost termination).

6.4 *Tolerances.* To comply with this standard, measured test results shall not be less than 95% of the Published Rating for performance ratios and capacities.

Section 7. Minimum Data Requirements for Published Ratings

7.1 *Minimum Data Requirements for Published Ratings.* Published Ratings shall include all Standard Ratings. All claims to ratings within the scope of this standard shall include the verbiage "Rated in accordance with ARI Standard 390". All claims to ratings outside the scope of this standard shall include the verbiage "Outside the scope of ARI Standard 390". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

7.1.1 *Capacity Designations.* Capacities used in published specifications, literature or advertising, controlled by the manufacturer, for equipment rated under this standard, are to be expressed only in Btu/h [W] at the Standard Rating Conditions specified in 5.2 plus Part-Load Rating Conditions specified in 5.2.4 and in the terms described in 6.1.1 and 6.1.2.



Note: The curve is based on following equation:

$$PLF = A0 + (A1 \times Q) + (A2 \times Q^2) + (A3 \times Q^3) + (A4 \times Q^4) + (A5 \times Q^5) + (A6 \times Q^6)$$

where: PLF = Part-Load Factor
Q = Percent of full-load capacity at part-load rating conditions.

$A0 = -0.12773917 \times 10^{-6}$
$A1 = -0.27648713 \times 10^{-3}$
$A2 = 0.50672449 \times 10^{-3}$
$A3 = -0.25966636 \times 10^{-4}$
$A4 = 0.69875354 \times 10^{-6}$
$A5 = -0.76859712 \times 10^{-8}$
$A6 = 0.28918272 \times 10^{-10}$

Figure 1. Part-Load Factor Curve

7.1.2 *Moisture Removal Designation.* The moisture removal designation shall be published in the manufacturer's specifications and literature or a statement, in such publications, shall be made to advise the user that this information is available upon request. The value shall be expressed in one or more of the following forms:

a. Sensible Capacity/total capacity ratio and total capacity

b. Latent Capacity and total capacity

c. Sensible Capacity and total capacity

Section 8. Operating Requirements

8.1 *Operating Requirements.* To comply with this standard, any production unit shall meet the requirements detailed herein.

8.2 *Maximum High-Temperature Operation Test. SPVAC/SPVHP* equipment shall pass the appropriate high-temperature operation tests required with an indoor-side airflow rate as determined under 5.2.2 and an outdoor-side airflow rate as determined under 5.2.3.

8.2.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

8.2.2 *Voltages.* The test shall be run at the Range A minimum utilization voltage from ARI Standard 110, Table 1, based upon the unit's nameplate rated published voltage(s). This voltage shall be supplied at the unit's service connection and at rated frequency.

8.2.3 *Procedure.* The unit shall be operated for one hour at the temperature conditions and voltage specified.

8.2.4 *Requirements.* The unit shall operate continuously without interruption for one hour.

8.3 *Voltage Tolerance Test. SPVAC/SPVHP* equipment shall pass the following voltage tolerance test with an indoor-side coil airflow rate as determined under 5.2.2 and an outdoor-side airflow rate as determined under 5.2.3.

8.3.1 *Temperature Conditions.* Temperature conditions shall be maintained at the standard cooling (and/or standard heating, as required) steady state conditions as shown in Table 3.

8.3.2 *Voltages.*

8.3.2.1 Tests shall be run at the Range B minimum and maximum utilization voltages from ARI Standard 110, Table 1, based upon the unit's nameplate rated voltage(s). These voltages shall be supplied at the unit's service connection and at rated frequency. A lower minimum or a higher maximum voltage shall be used, if listed, on the nameplate.

8.3.2.2 The power supplied to single phase equipment shall be adjusted just prior to the shut-down period (see 8.3.3.2) so that the resulting voltage at the unit's service connection is 86% of nameplate rated voltage when the compressor motor is in locked-rotor. (For 200V or 208V nameplate rated equipment, the restart voltage shall be set at 180V when the compressor motor is in locked-rotor). Open circuit voltage for three-phase equipment shall not be greater than 90% of nameplate rated voltage.

8.3.2.3 Within one minute after the equipment has resumed continuous operation (see 8.3.4.3), the voltage shall be restored to the values specified in 8.3.2.1.

8.3.3 *Procedure.*

8.3.3.1 The equipment shall be operated for one hour at the temperature conditions and voltage(s) specified.

8.3.3.2 All power to the equipment shall be interrupted for a period sufficient to cause the compressor to stop (not to exceed five seconds) and then be restored.

8.3.4 *Requirements.*

8.3.4.1 During both tests, the equipment shall operate without failure of any of its parts.

8.3.4.2 The equipment shall operate continuously without interruption for the one hour period preceding the power interruption.

8.3.4.3 The unit shall resume continuous operation within two hours of restoration of power and shall then operate continuously for one half hour. Operation and resetting of safety devices prior to establishment of continuous operation is permitted.

8.4 *Low-Temperature Operation Test (Cooling). SPVAC/SPVHP* equipment shall pass the following low-temperature operation test when operating with initial air flow rates as determined in 5.2.2 and 5.2.3 and with controls, fans, dampers, and grilles set to produce the maximum tendency to frost or ice the evaporator, provided such settings are not contrary to the manufacturer's instructions to the user.

8.4.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

8.4.2 *Procedure.* The test shall be continuous with the unit in the cooling cycle, for not less than four hours after establishment of the specified temperature conditions. The unit will be permitted to start and stop under control of an automatic limit device, if provided.

8.4.3 *Requirements.*

8.4.3.1 During the entire test, the equipment shall operate without damage or failure of any of its parts.

8.4.3.2 During the entire test, the air flow rate shall not drop more than 25% from that determined under the Standard Rating test.

8.4.3.3 During the test, and during the defrosting period after the completion of the test, all ice or meltage shall be caught and removed by the drain provisions.

8.5 *Insulation Effectiveness Test (Cooling). SPVAC/SPVHP* equipment shall pass the following insulation effectiveness test when operating with air flow rates as determined in 5.2.2 and 5.2.3 with controls, fans, dampers, and grilles set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's instructions to the user.

8.5.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

8.5.2 *Procedure.* After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of four hours.

8.5.3 *Requirements.* During the test, no condensed water shall drip, run, or blow off from the unit's casing.

8.6 *Condensate Disposal Test (Cooling). SPVAC/SPVHP* equipment which rejects condensate to the condenser air shall pass the following condensate disposal test when operating with air flow rates as determined in 5.2.2 and 5.2.3. Controls, fans, dampers, and grilles shall be set to produce condensate at the maximum rate, provided such settings are not contrary to the manufacturer's instructions to the user.

Note: This test may be run concurrently with the insulation effectiveness test (See 8.5).

8.6.1 *Temperature Conditions.* Temperature conditions shall be maintained as shown in Table 3.

8.6.2 *Procedure.* After establishment of the specified temperature conditions, the equipment shall be started with its condensate collection pan filled to the overflowing point and shall be operated continuously for four hours after the condensate level has reached equilibrium.

8.6.3 *Requirements.* During the test and after the unit is turned off, there shall be no dripping, running-off, or blowing-off of moisture from the unit casing.

8.7 *Tolerances.* The conditions for the tests outlined in Section 8 are average values subject to tolerances of ± 1.0oF [± 0.6oC] for air wet bulb and dry bulb temperatures, and
± 1.0% of the reading for voltages.

Section 9. Marking and Nameplate Data

9.1 *Marking and Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model designation, and electrical characteristics.

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of ARI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publication 60038.

Section 10. Conformance Conditions

10.1 *Conformance*. While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its the standard's *Purpose* (Section 1) and *Scope* (Section 2)

unless such product claims meet all the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard cannot reference, state, or acknowledge the standard in any written, oral, or electronic communication.

APPENDIX A. REFERENCES - NORMATIVE

A1 Listed here are all standards, handbooks and other publications essential to the formation and implementation of the standards. All references in this appendix are considered as part of the standard.

~~**A1.1** ANSI/ARI Standard 310/380-93, *Packaged Terminal Air-Conditioners and Heat Pumps*, Air-Conditioning and Refrigeration Institute, 1993, 4301 North Fairfax Drive, Suite 425, Arlington, VA 22203, U.S.A.~~

A1.21 ANSI/ASHRAE Standard 37, *Methods of Testing for Rating Unitary Air-Conditioning and Heat Pump Equipment*, 1988, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

A1.32 ARI Standard 110-972002, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages*, Air-Conditioning and Refrigeration Institute, 19972002, 4100301 North Fairfax Drive, Suite 425200, Arlington, VA 22203, U.S.A.

A1.43 ARI Standard 210/240-942003, *Unitary Air-Conditioning and Air-Source Heat Pump Equipment*, Air-Conditioning and Refrigeration Institute, 19942003, 43014100 North Fairfax Drive, Suite 425200, Arlington, VA 22203, U.S.A.

A1.54 ARI Standard 340/360-2000, *Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, Air-Conditioning and Refrigeration Institute, 2000, 43014100 North Fairfax Drive, Suite 425200, Arlington, VA 22203, U.S.A.

A1.65 *ASHRAE Terminology of Heating, Ventilation, Air Conditioning & Refrigeration*, Second Edition, 1991, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle NE, Atlanta, GA 30329, U.S.A

A1.76 IEC Standard Publication 60038, *IEC Standard Voltages*, International Electrotechnical Commission, 1983, 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland.

~~**A1.8** ISO 13256-1, *Water-Source Heat Pumps-Testing and Rating for Performance-Part 1: Water-to-Air and Brine-to-Air Heat Pumps*, 1998, International Organization for Standardization, Case Postale 56, CH-1211, Geneva 20, Switzerland.~~

APPENDIX B. REFERENCES - INFORMATIVE

None.

APPENDIX C. METHOD AND EXAMPLE OF CALCULATING INTEGRATED PART-LOAD VALUES (*IPLV*) – NORMATIVE

C1 *Purpose and Scope.*

C1.1 *Purpose.* This appendix shows sample calculations for determining Integrated Part Load Values (*IPLV*).

C1.2 *Scope.* This appendix is for equipment covered by this standard.

C2 *Equations and Definition of Terms.*

C2.1 *General Equation.*

$$IPLV = \left(PLF_1 - PLF_2\right) \times \frac{\left(EER_1 + EER_2\right)}{2} + \left(PLF_2 - PLF_3\right) \times \frac{\left(EER_2 + EER_3\right)}{2} + \left(PLF_{n-1} - PLF_n\right) \times \frac{\left(EER_{n-1} + EER_n\right)}{2} + \left(PLF_n\right) \times \left(EER_n\right)$$

where:

PLF	=	Part-load factor determined from Figure 1
n	=	Total number of capacity steps
Superscript 1	=	100% capacity and *EER* at part-load Rating Conditions
Subscript 2, 3 etc.	=	Specific capacity and *EER* at part-load steps per 6.2 of this standard

C3 *Calculation Example for a Four Capacity Step System.*

C3.1 *Unit Performance Data & Sample Calculation.*

C3.1.1 Assume equipment has four capacity steps as follows:

1 100% (full load)
2 75% of full load
3 50% of full load
4 25% of full load

C3.1.2 Obtain part-load factors from Figure C1.

C3.1.3 Obtain *EER* at each capacity step per 6.2 of this standard.

C3.1.4 Calculate *IPLV* using the general equation with:

n = 4

$PLF_1 = 1.0$	$EER_1 = 8.9$
$PLF_2 = 0.9$	$EER_2 = 7.7$
$PLF_3 = 0.4$	$EER_3 = 7.1$
$PLF_4 = 0.1$	$EER_4 = 5.0$

Enter the above values in the equation in Section C2.1.

$$IPLV = \left(1.0 - 0.9\right) \times \frac{\left(8.9 + 7.7\right)}{2}$$

$$+ \left(0.9 - 0.4\right) \times \frac{\left(7.7 + 7.1\right)}{2}$$

$$+ \left(0.4 - 0.1\right) \times \frac{\left(7.1 + 5.0\right)}{2}$$

$$+ \left(0.1\right) \times \left(5.0\right)$$

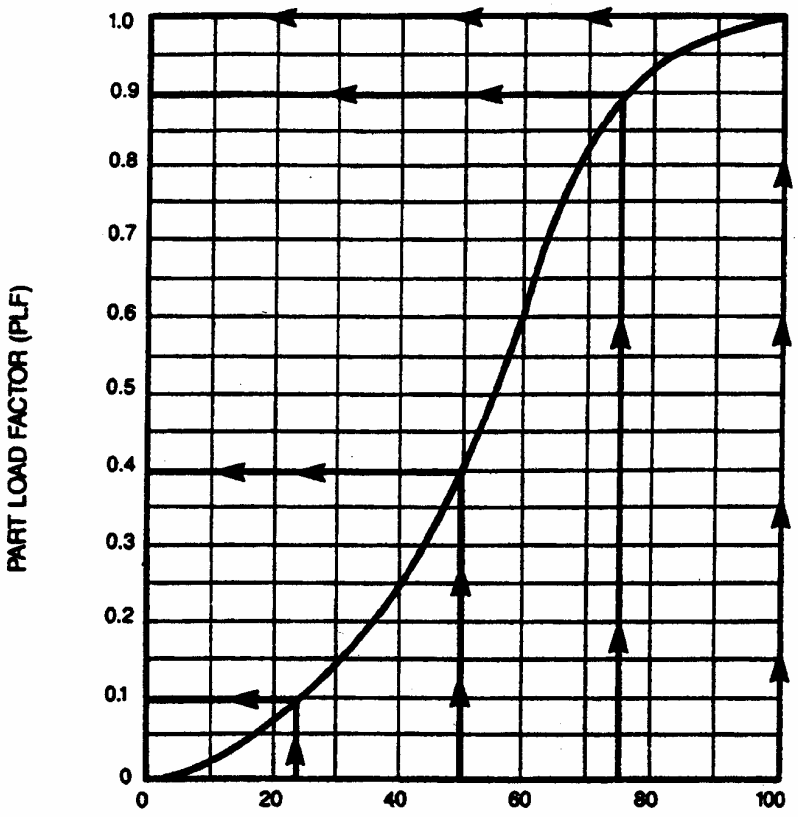
$$= \left(0.1 \times 8.3\right) + \left(0.5 \times 7.4\right)$$

$$+ \left(0.3 \times 6.0\right) + \left(0.5\right)$$

$$= \left(0.83 + 3.70 + 1.80 + 0.5\right)$$

$$IPLV = 6.83 rounded to 6.8$$

To further illustrate the calculation process, see the example in Table C1.



Note: The curve is based on following equation:

$$PLF = A0 + (A1 \times Q) + (A2 \times Q^2) + (A3 \times Q^3) + (A4 \times Q^4) + (A5 \times Q^5) + (A6 \times Q^6)$$

where: PLF = Part-Load Factor
Q = Percent of full-load capacity at part-load rating conditions.

$A0 = -0.12773917 \times 10^{-6}$
$A1 = -0.27648713 \times 10^{-3}$
$A2 = 0.50672449 \times 10^{-3}$
$A3 = -0.25966636 \times 10^{-4}$
$A4 = 0.69875354 \times 10^{-6}$
$A5 = -0.76859712 \times 10^{-8}$
$A6 = 0.28918272 \times 10^{-10}$

Figure C1. Part -Load Factor Example

I-P Units

Using information from C3.1:

Table C1. Example *IPLV* Calculation

Capacity Step	% Full Load Cap.[1]	PLF[2]	Mfrs. Part-Load *EER*	Avg. Part-Load *EER*	PLF Diff.	Avg. *EER* x PLF Diff. =	Weighted Avg.
1	100%	1.0	8.9[1] =	8.3	(1.0 - 0.9) = 0.1	8.3 x 0.1 =	0.83
2	75%	0.9	7.7 =	7.4	(0.9 - 0.4) = 0.5	7.4 x 0.5 =	3.70
3	50%	0.4	7.1 =	6.0	(0.4 - 0.1) = 0.3	6.0 x 0.3 =	1.80
4	25%	0.1	5.0 =	5.0[3]	(0.1 - 0.0) = 0.1	5.0 x 0.1 =	0.50
	0%	0.0		-----		Single number *IPLV*	6.83*

* Rounded to 6.8

NOTES:
1 The 100% capacity and *EER* are to be determined at the part-load Rating Conditions.
2 Part-load factor from Figure C1.
3 For the range between 0% capacity and the last capacity step, use *EER* of the last capacity step for the average *EER*.

EXHIBIT 2: SPVAC EER vs SEER (<65,000 Btu/h)

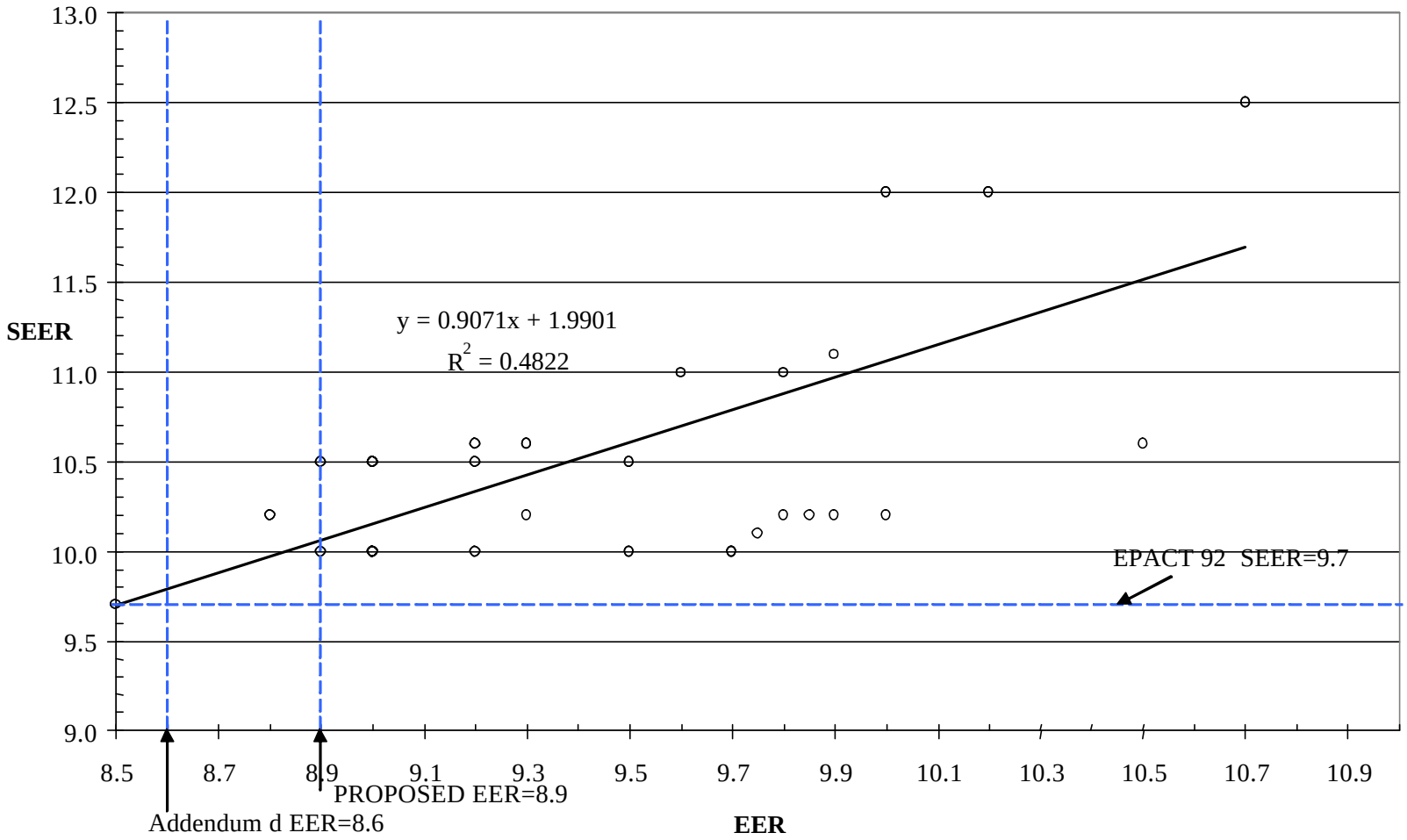


EXHIBIT 3: SPVHP EER vs SEER (<65,000 Btu/h)

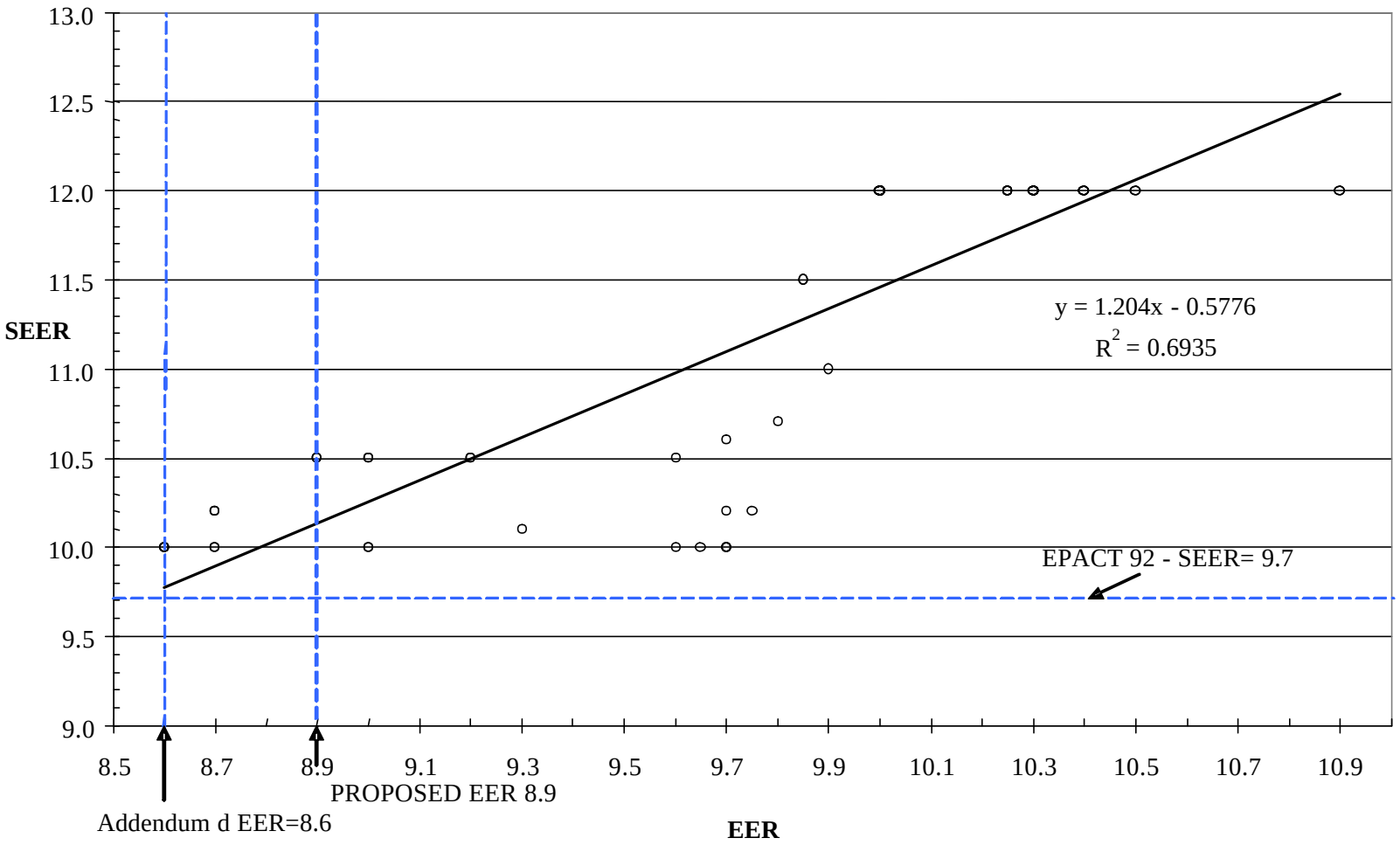


EXHIBIT 4: SPVHP COP vs. HSPF (<65,000 Btu/h)